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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)
	10/560,001	TOMOZAWA ET AL.
	Examiner	Art Unit
	ALEXANDER C. WITKOWSKI	2853

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08 May 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-11 and 24-37* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-11 and 24-37* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *12/08/2005*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1, 6, 8 - 11, 24, 29, 31, 32, 34 - 37 are rejected under 35 U.S.C. 103(a) as being unpatentable over Murai (US 6,705,708); Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films.

With respect to claim 1, Murai '708 teaches **a piezoelectric element** (Fig.6: 40) **comprising a first electrode film** (Fig.6: 33)**, a layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **including a first thin piezoelectric film** (Fig.6: 43a) **provided on the first electrode film and a second thin piezoelectric film** (col.8, lines 1-8) **provided on the first thin piezoelectric film and a second electrode film** (Fig.6: 44) **provided on the layered piezoelectric film, wherein the layered piezoelectric film is made of rhombohedral** (col.7, lines 17-20) **or tetragonal perovskite oxide** (col.5, lines 21-24)

having preferred orientation along the 111 plane (col.8, lines 43-47)**, the first and second thin piezoelectric films are aggregates of columnar grains** (the first and second thin piezoelectric films are rhombohedral grains, which are columnar)**, respectively, which are continuously linked to each other** (col.8, lines 34-38, lines 48-52)**, the columnar grains of the second thin piezoelectric film have a larger average cross-sectional diameter than the columnar grains of the first thin piezoelectric film** (col.8, lines 21-23) **and the thickness of the layered piezoelectric film** (col.8, lines 8-9: disclosing layered piezoelectric film thickness of 1.5 microns).

However, Murai '708 does not teach **the ratio of the thickness of the layered piezoelectric film to the average cross-sectional diameter of the columnar grains of the second thin piezoelectric film is 20 to 60 inclusive.**

Qui et al. teaches a piezoelectric film having PZT crystal with columnar grain diameter of 100 to 400 nm (col.11, lines 2-4). Cheng et al., Table 1: discloses PZT film thickness of 3300 nm. Sumi et al.: p.7, lines 14-17, discloses PZT grains 30 nm in diameter. These combined references teach a ratio of the thickness of the layered piezoelectric film to the average cross-sectional diameter of the columnar grains of the second thin piezoelectric film is 8.2 to 33 for 3300 nm film, and 50 to 133 for the 1500 film, inclusive, of which 20 to 60 is claimed.

It would have been obvious to one of ordinary skill in the art at the time that this invention was made to modify Murai '708 to use PZT crystals with columnar grain diameter of 100 to 400 nm and film thicknesses of 1500 nm or 3300 nm, as taught by the combination of Qui et al., Cheng et al., and Sumi et al. references, such that the

ratio of the thickness of the layered piezoelectric film to the average cross-sectional diameter of the columnar grains of the second thin piezoelectric film is 8.2 to 33 for 3300 nm film, and 50 to 133 for the 1500 nm film, for the purpose reducing comparative grain size in order to improve bonding between films.

With respect to claim 6, the combination of Murai ‘708, Qiu et al., Cheng et al. and Sumi et al. references, as applied to claim 1, teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **is made of lead zirconate titanate added with at least one of magnesium and manganese in an amount of more than 0 and not more than 10 mol%** (col.5, lines 22-26)**.**

With respect to claim 8, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 1, teaches **an inkjet head** (Murai ‘708: Fig.1:1) **comprising: a piezoelectric element** (Fig.6: 40) **including a first electrode film** (Fig.6: 33)**, a layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **including a first thin piezoelectric film** (Fig.6: 43a) **and a second thin piezoelectric film** (Fig.6: 43) **and a second electrode film** (Fig.6: 44) **stacked in this order; a diaphragm layer** (Fig.6: 30, 31, 32; col.2, lines 1-2) **disposed on the second electrode film side surface of the piezoelectric element** (Fig.6: 32; col.2, lines 8-11)**; and a pressure chamber member** (Fig.6: 20) **including a pressure chamber** (Fig.6: 21) **for containing ink which is bonded to the surface of the diaphragm layer opposite to**

the second electrode film, such that the ink in the pressure chamber is discharged out by displacing the diaphragm layer in the thickness direction by the piezoelectric effect of the layered piezoelectric film (col.3, lines 1-4)**.**

With respect to claim 10, the combination of Murai '708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 8, teaches **an inkjet recording device** (Murai '708: Fig.1) **comprising an inkjet head** (Fig.1: 1) **and a relative movement mechanism for relatively moving the inkjet head and a recording medium** (Fig.1: 1, 4, 5, 6, 7)**, wherein recording is carried out by discharging the ink in the pressure chamber** (Fig.6: 21) **from a nozzle hole** (Fig.4: 11) **communicating with the pressure chamber onto the recording medium while the inkjet head and the recording medium are relatively moved by the relative movement mechanism.**

With respect to claim 9, the combination of Murai '708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 1, teaches **an inkjet head** (Murai '708: Fig.1:1) **comprising: a piezoelectric element** (Fig.6: 40) **including a first electrode film** (Fig.6: 33)**, a layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **including a first thin piezoelectric film** (Fig.6: 43a) **and a second thin piezoelectric film** (Fig.6: 43) **and a second electrode film** (Fig.6: 44) **stacked in this order; a diaphragm layer** (Fig.6: 30, 31, 32; col.2, lines 1-2) **disposed on the first electrode film side surface of the piezoelectric element** (Fig.6: 31; col.2, lines 3-4)**; and a pressure chamber member** (Fig.6: 20) **including a pressure chamber** (Fig.6: 21) **for containing ink**

which is bonded to the surface of the diaphragm layer opposite to the first electrode film, such that the ink in the pressure chamber is discharged out by displacing the diaphragm layer in the thickness direction by the piezoelectric effect of the layered piezoelectric film (col.3, lines 1-4)**.**

With respect to claim 11, the combination of Murai '708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 9, teaches **an inkjet recording device** (Murai '708: Fig.1) **comprising an inkjet head** (Fig.1: 1) **and a relative movement mechanism for relatively moving the inkjet head and a recording medium** (Fig.1: 1, 4, 5, 6, 7)**, wherein recording is carried out by discharging the ink in the pressure chamber** (Fig.6:21) **from a nozzle hole** (Fig.4: 11) **communicating with the pressure chamber onto the recording medium while the inkjet head and the recording medium are relatively moved by the relative movement mechanism.**

With respect to claim 24, the combination of Murai '708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 1, teaches **a piezoelectric element** (Murai '708: Fig.6: 40) **further comprising an orientation control film disposed between the first electrode film** (Fig.6: 33) **and the first thin piezoelectric film** (Fig.6: 43a)**, wherein the orientation control film is made of cubic or tetragonal perovskite oxide having preferred orientation along the 111 plane** (col.12, lines 30-35)**.**

With respect to claim 29, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 24, teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the orientation control film is made of oxide based on perovskite lead lanthanum zirconate titanate and the degree of 111 crystal orientation of the orientation control film is 50% or more** (col.12, lines 30-35)**.**

With respect to claim 31, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 24, teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the orientation control film is made of lead lanthanum zirconate titanate added with at least one of magnesium and manganese in an amount of more than 0 and not more than 10 mol%** (col.5, lines 22-26)**.**

With respect to claim 32, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 24, teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **is made of lead zirconate titanate added with at least one of magnesium and manganese in an amount of more than 0 and not more than 10 mol%** (col.5, lines 22-26)**.**

With respect to claim 34, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 24, teaches **an inkjet head** (Murai ‘708:

Fig.1: 1) **comprising: a piezoelectric element** (Fig.6: 40) **including a first electrode film** (Fig.6: 33)**, an orientation control film, a layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **including a first thin piezoelectric film** (Fig.6: 43a) **and a second thin piezoelectric film** (Fig.6: 43) **and a second electrode film** (Fig.6: 44) **stacked in this order; a diaphragm layer disposed on the second electrode film side surface of the piezoelectric element; and a pressure chamber member** (Fig.6: 20) **including a pressure chamber** (Fig.6: 21) **for containing ink which is bonded to the surface of the diaphragm layer opposite to the second electrode film, such that the ink in the pressure chamber is discharged out by displacing the diaphragm layer in the thickness direction by the piezoelectric effect of the layered piezoelectric film** (col.3, lines 1-4)**.**

With respect to claim 35, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 24, teaches **an inkjet head** (Murai ‘708: Fig.1: 1) **comprising: a piezoelectric element** (Fig.6: 40) **including a first electrode film** (Fig.6: 33)**, an orientation control film, a layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **including a first thin piezoelectric film** (Fig.6: 43a) **and a second thin piezoelectric film** (Fig.6: 43) **and a second electrode film** (Fig.6: 44) **stacked in this order; a diaphragm layer disposed on the first electrode film side surface of the piezoelectric element; and a pressure chamber member** (Fig.6: 20) **including a pressure chamber** (Fig.6: 21) **for containing ink which is bonded to the surface of the diaphragm layer opposite to the first electrode film, such that the ink in the**

pressure chamber is discharged out by displacing the diaphragm layer in the thickness direction by the piezoelectric effect of the layered piezoelectric film (col.3, lines 1-4)**.**

With respect to claim 36, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 34, teaches **an inkjet recording device** (Murai ‘708: Fig.1) **comprising an inkjet head** (Fig.1: 1) **and a relative movement mechanism for relatively moving the inkjet head and a recording medium** (Fig.1: 1, 4, 5, 6, 7)**, wherein recording is carried out by discharging the ink in the pressure chamber** (Fig.6: 21) **from a nozzle hole** (Fig.4: 11) **communicating with the pressure chamber onto the recording medium while the inkjet head and the recording medium are relatively moved by the relative movement mechanism.**

With respect to claim 37, the combination of Murai ‘708, Qiu et al., Cheng et al., and Sumi et al. references, as applied to claim 35, teaches **an inkjet recording device** (Murai ‘708: Fig.1) **comprising an inkjet head** (Fig.1: 1) **and a relative movement mechanism for relatively moving the inkjet head and a recording medium** (Fig.1: 1, 4, 5, 6, 7)**, wherein recording is carried out by discharging the ink in the pressure chamber** (Fig.6: 21) **from a nozzle hole** (Fig.4: 11) **communicating with the pressure chamber onto the recording medium while the inkjet head and the recording medium are relatively moved by the relative movement mechanism.**

3. Claims 2 and 25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Murai (US 6,705,708); Qiu et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films; and further in view of Miyasaka (US 2002/0168831); and Barzegar: Study of Size (Aspect Ratio) Effect on Longitudinal Piezoelectric Coefficient Measured by Quasistatic Technique, 2002 IEEE Ultrasonics Symposium.

With respect to claim 2, the combination of Murai '708, Qiu et al., Cheng et al., Sumi et al. references teaches all the limitations of claim 2 except that **the columnar grains of the first thin piezoelectric film have an average cross-sectional diameter of 40 nm to 70 nm inclusive and a length of 5 nm to 100 nm inclusive**.

Miyasaka teaches that **the columnar grains of the first thin piezoelectric film have an average cross-sectional diameter of 40 nm to 70 nm inclusive** (Miyasaka: [0074]: disclosing columnar grain diameter of 50 nm in a film). Barzegar teaches **a length of 5 nm to 100 nm inclusive** (Barzegar: disclosing PZT crystal aspect ratio 0.1 to 2.0, for which a 50 nm diameter grain is 0.1 x 50 = 5 nm in length, and is 2.0 x 50 = 100 nm in length).

It would have been obvious to one of ordinary skill in the art at the time of this invention to modify the combination of Murai '708, Qiu et al., Cheng et al., and Sumi et

al. references to provide that the columnar grains of the first thin piezoelectric film have an average cross-sectional diameter of 40 nm to 70 nm inclusive and a length of 5 nm to 100 nm inclusive, as taught by the combination of Miyasaka and Barzegar references, for the purpose of reducing comparative grain size in order to improve bonding between films.

With respect to claim 25, the combination of Murai ‘708, Qiu et al., Cheng et al., Sumi et al., Miyasaka, and Barzegar references, as applied to claim 24, teaches all the limitations of claim 25 except **a piezoelectric element** (Murai ‘708: Fig.6: 40) **wherein the columnar grains of the first thin piezoelectric film** (Fig.6: 43a) **have an average cross-sectional diameter of 40 nm to 70 nm inclusive** (Miyasaka: [0074]: disclosing columnar grain diameter of 50 nm in a film) **and a length of 5 nm to 100 nm inclusive** (Barzegar: disclosing PZT crystal aspect ratio 0.1 to 2.0, for which a 50 nm diameter grain is 0.1 x 50 = 5 nm in length, and is 2.0 x 50 = 100 nm in length).

4. Claims 7 and 33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Murai (US 6,705,708); Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44)

0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films; and further in view of Takamatsu et al. (US 6,624,458).

With respect to claim 7, the combination of Murai ‘708, Qui et al., Cheng et al., and Sumi et al. references, as applied to claim 1, teaches that **the first electrode film is made of noble metal of Pt, Ir, Pd or Ru or an alloy containing the noble metal** (Murai ‘708: col.6, line 42). However, the combination of Murai ‘708, Qui et al., Cheng et al., and Sumi et al. references does not teach that the first electrode film **is an aggregate of columnar grains having an average cross-sectional diameter of 20 nm to 30 nm inclusive.**

Takamatsu et al. teaches that the first electrode film is an aggregate of columnar grains having an average cross-sectional diameter of 20 nm to 30 nm inclusive. (Takamatsu et al.: col.7: lines 29-31: disclosing IrOx with columnar grains of 20 to 50 nm diameter).

It would have been obvious to one of ordinary skill in the art at the time of this invention to modify the combination of Murai ‘708, Qui et al., Cheng et al., and Sumi et al. references, as taught by Takamatsu et al., so that the first electrode film is an aggregate of columnar grains having an average cross-sectional diameter of 20 nm to 30 nm inclusive in order to achieve improved inter-film adhesion.

With respect to claim 33, the combination of Murai ‘708, Qiu et al., Cheng et al., Sumi et al., and Takamatsu et al. references, as applied to claim 24, teaches **a**

piezoelectric element (Murai ‘708: Fig.6: 40)**, wherein the first electrode film** (Fig.6: 33) **is made of noble metal of Pt, Ir, Pd or Ru or an alloy containing the noble metal** (col.6, line 42) **and is an aggregate of columnar grains having an average cross-sectional diameter of 20 nm to 30 nm inclusive** (Takamatsu et al.: col.7: lines 29-31: disclosing IrOx with columnar grains of 20 to 50 nm diameter)**.**

5. Claims 3 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Murai (US 6,705,708); Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films, in view of Takamatsu et al. (US 6,624,458).

With respect to claim 3, the combination of Murai ‘708, Qui et al., Cheng et al, and Sumi et al. references, as applied to claim 1, teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the columnar grains of the second thin piezoelectric film** (Fig.6: 43a, 43) **have an average cross-sectional diameter of 60 nm to 200 nm inclusive** (Qui et al.: Abstract, lines 9-12: disclosing PZT columnar grain diameter range of 100 nm to 15,000 nm) **and a length of 2500 nm to 5000 nm inclusive** (Abstract, lines 9-12)**.**

With respect to claim 26, the combination of Murai '708, Qiu et al., Cheng et al., and Sumi et al. references teaches all the limitations of claim 26, as discussed in the 103 rejection of claim 3. Therefore claim 26 is rejected for the same reasons.

6. Claims 4, 5, 27, 28, and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Murai (US 6,705,708); Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films, and further in view of Takamatsu et al. (US 6,624,458), Murai (US 6,494,567), and Murai (US 7,083,269).

With respect to claim 4, the combination of Murai '708, Qui et al., Cheng et al., and Sumi et al. references teaches all the limitations of claim 1, discussed above.

However, the combination of Murai '708, Qui et al., Cheng et al., and Sumi et al. references does not teach **a piezoelectric element according to claim 1, wherein the first and second thin piezoelectric films are made of oxide based on perovskite lead zirconate titanate, the degree of 111 crystal orientation of the first thin piezoelectric film is 50 % to 80 % inclusive and the degree of 111 crystal orientation of the second thin piezoelectric film is 95 % to 100 % inclusive.**

Murai '567 teaches **a piezoelectric element according to claim 1, wherein the**

first and second thin piezoelectric films are made of oxide based on perovskite lead zirconate titanate, the degree of 111 crystal orientation of the first thin piezoelectric film is 50 % to 80 % inclusive (Murai, ‘567: Abstract: lines 5-9, disclosing orientation of 100 face at 40 - 70%, 110 face at 10%, therefore 11 face is at 50 - 70%). Murai ‘269 teaches that **the degree of 111 crystal orientation of the second thin piezoelectric film is 95 % to 100 % inclusive** (Murai, ‘269: col.2, lines 1-5: disclosing thin film orientation in the 111 plane of 90% or more**).**

It would have been obvious to one of ordinary skill in the art at the time that this invention was made to modify the combination of Murai ‘708, Qui et al., Cheng et al., and Sumi et al. references to provide that the first and second thin piezoelectric films are made of oxide based on perovskite lead zirconate titanate, the degree of 111 crystal orientation of the first thin piezoelectric film is 50 % to 70 % inclusive, as taught by Murai ‘567, and the degree of 111 crystal orientation of the second thin piezoelectric film is 95 % to 100 % inclusive, as taught by Murai ‘269, in order to achieve improved crystallinity (Murai ‘567: Abstract, lines 10-13).

With respect to claim 5, the combination of Murai ‘708, Qui et al., Cheng et al., Sumi et al., Takamatsu et al., Murai ‘567, and Murai ‘269 teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40) **according to claim 1, wherein the chemical composition ratio of the layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **is represented as**

[Pb] : [Zr] : [Ti] = (l + a) : b : (1 - b),

the first and second thin piezoelectric films (Fig.6: 43a, 43) **have the same value b of 0.40 to 0.60 inclusive, the first thin piezoelectric film has a larger Pb content than the second thin piezoelectric film** (Takamatsu et al.: col.14, lines 32-34)**, the first thin piezoelectric film** (Murai, ‘708: Fig.6: 43a) **has the value a of 0.05 to 0.15 inclusive and the second thin piezoelectric film has the value a of 0 to 0.10 inclusive** (Murai ‘269: col.4, lines 58-63)**.**

With respect to claim 27, the combination of Murai ‘708, Qui et al., Cheng et al., Sumi et al., Takamatsu et al., Murai ‘567, and Murai ‘269 teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the first and second thin piezoelectric films** (Fig.6: 43a, 43) **are made of oxide based on perovskite lead zirconate titanate, the degree of 111 crystal orientation of the first thin piezoelectric film is 50 % to 80 % inclusive** (Murai, ‘567: Abstract: disclosing orientation of 100 face at 40 – 70%, 110 face at 10%, therefore 11 face is at 50 – 70%) **and the degree of 111 crystal orientation of the second thin piezoelectric film is 95 % to 100 % inclusive** (Murai, ‘269: col.2, lines 1-5: disclosing thin film orientation in the 111 plane of 90% or more)**.**

With respect to claim 28, the combination of Murai ‘708, Qui et al., Cheng et al., Sumi et al., Takamatsu et al., Murai ‘567, and Murai ‘269 teaches **a piezoelectric element** (Murai ‘708: Fig.6: 40)**, wherein the chemical composition ratio of the layered piezoelectric film** (Fig.6: 43; col.8, lines 1-8) **is represented as**

[Pb] : [Zr] : [Ti] = (1 + a) : b : (1 - b),

the first and second thin piezoelectric films (Fig.6: 43a, 43) **have the same value b of 0.40 to 0.60 inclusive, the first thin piezoelectric film has a larger Pb content than the second thin piezoelectric film** (Takamatsu et al.: col.14, lines 32-34)**, the first thin piezoelectric film has the value a of 0.05 to 0.15 inclusive and the second thin piezoelectric film has the value a of 0 to 0.10 inclusive** (Murai '269: col.4, lines 58-63)**.**

With respect to claim 30, the combination of Murai '708, Qui et al., Cheng et al., Sumi et al., Takamatsu et al., Murai '567, and Murai '269 references teaches **a piezoelectric element** (Murai '708: Fig.6: 40)**, wherein the chemical composition ratio of the orientation control film is represented as**

[Pb] : [La] : [Zr] : [Ti] = x times **(1-z) : z : y : (1 - y), the value x is 1.0 to 1.20 inclusive, the value y is 0 to 0.20 inclusive and the value z is more than 0 and not more than 0.30** (Murai '269: col.4, lines 58-63)**.**

Response to Arguments

7. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

8. In accordance with Applicants' request, the Examiner has initialed the US 6,194,818 reference as having been considered.

9. Applicant's arguments, see Amendment / After Non-Final Rejection filed 05/08/2008, with respect to the rejection of claims 1, 2, 6 - 11, 24, 25, 29, 31 - 37 under 103 have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view of Murai (US 6,705,708); Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films.

10. In a traversal of the 103 rejections, Applicants argue that:

a. The Examiner states that Murai discloses that "a layered piezoelectric film including a first thin piezoelectric film and a second thin piezoelectric film has preferred orientation along the (111) plane (see column 8, lines 43-47)."

As shown in S1-S5 of Fig. 5, Murai forms, first of all, a piezoelectric layer 43a corresponding to the first thin piezoelectric film of the present invention. The piezoelectric layer 43a has preferred orientation along a 100 plane (in column 7, lines 25-28, the layer 43a has a 100 plane orientation degree of no less than 80%). Then, a hole is formed in the piezoelectric layer 43a (S4) and a piezoelectric layer 43 is stacked. As a result, a part of the piezoelectric layer 43

that is formed on the piezoelectric layer 43a (there is no hole) has preferred orientation along the 100 plane. On the other hand, a part of the piezoelectric layer 43 that is formed in a place where a ZrO2 film 32 is exposed has preferred orientation along a 111 plane (see column 8, lines 39-47). The portion with no hole has a two-layer structure of the piezoelectric layer 43a having preferred orientation along a 100 plane and the piezoelectric layer 43 above the layer 43a having preferred orientation along a 100 planed. In this way, the layered piezoelectric film of Murai has preferred orientation along the 100 plane, which is different from the present invention characterized in that the layered piezoelectric film has preferred orientation along the 111 plane. On the other hand, as stated in the Office Action, the part of the piezoelectric layer 43 formed in the place where a ZrO2 film 32 is exposed has preferred orientation along the 111 plane (column 8, lines 43-47 of Mural). However, the layer 43 comprises only one piezoelectric film, not a layered piezoelectric film including a first thin piezoelectric film and a second thin piezoelectric film like the present invention. In this way, Mural neither discloses nor suggests the element of the present invention characterized in that the layered piezoelectric film including a first thin piezoelectric film and a second thin piezoelectric film is made of perovskite oxide having preferred orientation along the (111) plane.

Examiner responds to Applicants argument a. by respectfully noting that the more complete restatement of claim 1 would include “a first electrode film” and “a

second electrode film." These limitations reinforce the concept of the two-layered aspect of piezoelectric layer 43 described in Murai '708, which is clearly cited in the 03/31/2008 Office action. While Applicants' assertions are not inconsistent with Murai '708, they do not recognize that Murai '708, at S5, discloses assembly of layer 43 in two or more layers as cited in the 03/31/2008 Office action at column 8, lines 1-9. Nor do they recognize that Murai '708 specifically states, and shows, at figure 5, S4, S5, that "a portion formed in the zone from which the bottom electrode 33 was removed by patterning and where the ZrO2 film 32 was exposed is affected by the Ti layer and has a large orientation in 111 plane."

b. Applicants argue that the Examiner states that Murai discloses that "the columnar grains of the second thin piezoelectric film have a larger average cross-sectional diameter than the columnar grains of the first thin piezoelectric film (see column 8, lines 21-23)." As shown in S5 of Fig. 5, Murai just discloses that the total thickness of the second piezoelectric layer 43 (formed by the second forming step) is greater than the thickness of first piezoelectric layer 43a (formed by the first forming step) (see column 8, lines 21-23). It appears that Murai neither discloses nor suggests that an average cross-sectional diameter of the columnar grains constituting the piezoelectric layer sectioned along the lateral direction. In other words, an average cross-sectional diameter is not considered in Murai, at all. Accordingly, Murai neither discloses nor suggests that the elements of the present invention characterized in that the columnar grains of the

second thin piezoelectric film have a larger average cross-sectional diameter than the columnar grains of the first thin piezoelectric film.

Examiner responds to Applicants argument b. by conceding its merit. Therefore, the rejection has been withdrawn. However, upon further consideration, new grounds of rejection are made based on Murai ‘708, in view of Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films.

c. Applicant argues that the Examiner states that Tatematsu et al. discloses that "the ratio of the thickness of the layered piezoelectric film to the average cross-sectional diameter of the columnar grains of the second thin piezoelectric film is 20 to 60 inclusive (see column 7, lines 29 - 31)." Tatematsu just discloses, in column 7, lines 29-31, that "the IrOx film 16 has a columnar microstructure composed of columnar crystals having a grain size of 20 - 50 nm." The IrOx film 16 is an upper electrode, not a piezoelectric layer (PZT). In other words, Tatematsu just discloses that "the IrOx film 16 has a columnar microstructure composed of columnar crystals having a grain size of 20 - 50 nm." The description is irrelevant to the piezoelectric film, even to the columnar grains of

the thin piezoelectric film, or the thickness of a layered piezoelectric film. In this way, Tatematsu neither discloses nor suggests the element of the present invention characterized in that "the ratio of the thickness of the layered piezoelectric film to the average cross-sectional diameter of the columnar grains of the second thin piezoelectric film is 20 to 60 inclusive."

Examiner responds to Applicants' argument c. by conceding its merit. Therefore, the rejection has been withdrawn. However, upon further consideration, new grounds of rejection are made based on Murai '708, in view of Qui et al. (US 6,402,304); Cheng et al.: Thin Solid Films, Vol.385, Issues 1-2, April 2001, pp.5-10, Thickness-dependent microstructures and electrical properties of PZT films derived from sol-gel process; and Sumi et al.: Thin Solid Films, Vol.315, Issues 1-2, March 1998, pp.77-85: Effect of the annealing temperature on structural and piezoelectric properties of the sol-gel Pb(Zr 0.56Ti 0.44) 0.90 (Mg 1/3 Nb 2/3) 0.10 O3 films.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ALEXANDER C. WITKOWSKI whose telephone number is (571)270-3795. The examiner can normally be reached on Monday - Friday 8:00 AM to 5:00 PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen D. Meier can be reached on 571-272-2149. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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ACW

/STEPHEN D. MEIER/

Supervisory Patent Examiner, Art Unit 2853